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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
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SCHWEGMAN, LUNDBERG, WOESSNER & KLUTH, P.A.  
P.O. BOX 2938  
MINNEAPOLIS, MN 55402

EXAMINER

BEREZNY, NEAL

ART UNIT PAPER NUMBER

2823

DATE MAILED: 03/31/2003

Please find below and/or attached an Office communication concerning this application or proceeding.

# Office Action Summary

Application No.

09/484,303

Applicant(s)

AHN ET AL.

Examiner

Neal Berezny

Art Unit

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-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --  
Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If the period for reply specified above is less than thirty (30) days, a reply within the statutory minimum of thirty (30) days will be considered timely.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133).
- Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

## Status

- 1) ☒ Responsive to communication(s) filed on 20 February 2003.
- 2a) ☐ This action is FINAL. 2b) ☒ This action is non-final.
- 3) ☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

## Disposition of Claims

- 4) ☒ Claim(s) 5-13 and 36-41 is/are pending in the application.
- 4a) Of the above claim(s) 36-41 is/are withdrawn from consideration.
- 5) ☐ Claim(s) \_\_\_\_\_ is/are allowed.
- 6) ☒ Claim(s) 5-13 is/are rejected.
- 7) ☐ Claim(s) \_\_\_\_\_ is/are objected to.
- 8) ☐ Claim(s) \_\_\_\_\_ are subject to restriction and/or election requirement.

## Application Papers

- 9) ☒ The specification is objected to by the Examiner.
- 10) ☒ The drawing(s) filed on 18 January 2000 is/are: a) ☒ accepted or b) ☐ objected to by the Examiner.  
Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).
- 11) ☐ The proposed drawing correction filed on \_\_\_\_\_ is: a) ☐ approved b) ☐ disapproved by the Examiner.  
If approved, corrected drawings are required in reply to this Office action.
- 12) ☐ The oath or declaration is objected to by the Examiner.

## Priority under 35 U.S.C. §§ 119 and 120

- 13) ☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).  
a) ☐ All b) ☐ Some \* c) ☐ None of:  
1. ☐ Certified copies of the priority documents have been received.  
2. ☐ Certified copies of the priority documents have been received in Application No. \_\_\_\_\_.  
3. ☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).  
\* See the attached detailed Office action for a list of the certified copies not received.
- 14) ☐ Acknowledgment is made of a claim for domestic priority under 35 U.S.C. § 119(e) (to a provisional application).  
a) ☐ The translation of the foreign language provisional application has been received.
- 15) ☐ Acknowledgment is made of a claim for domestic priority under 35 U.S.C. §§ 120 and/or 121.

## Attachment(s)

- 1) ☒ Notice of References Cited (PTO-892) 4) ☐ Interview Summary (PTO-413) Paper No(s) \_\_\_\_\_
- 2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948) 5) ☐ Notice of Informal Patent Application (PTO-152)
- 3) ☒ Information Disclosure Statement(s) (PTO-1449) Paper No(s) 3,4,5 6) ☐ Other: \_\_\_\_\_

## **DETAILED ACTION**

### **Acknowledgements**

1. Examiner acknowledges applicant's election, without traverse, of the Group I invention, claims 5-13, and the cancellation of claims 1-3, 22-28, and 32-35. Claims 36-41 are non-elected.

### ***Specification***

2. The disclosure is objected to because of the following informalities: Fig. 7, element 228 is not specifically identified in the specifications.

Appropriate correction is required.

### ***Claim Rejections - 35 USC § 112***

3. The following is a quotation of the first paragraph of 35 U.S.C. 112:

The specification shall contain a written description of the invention, and of the manner and process of making and using it, in such full, clear, concise, and exact terms as to enable any person skilled in the art to which it pertains, or with which it is most nearly connected, to make and use the same and shall set forth the best mode contemplated by the inventor of carrying out his invention.

4. Claim 7 is rejected under 35 U.S.C. 112, first paragraph, as containing subject matter which was not described in the specification in such a way as to enable one skilled in the art to which it pertains, or with which it is most nearly connected, to make and/or use the invention. Claim 5 requires that the conductive structure is formed first and then the barrier layer, whereas, claim 7, which depends on claim 5, requires the conductive structure is formed on the barrier layer, thus reversing the order of claim 5.

5. The following is a quotation of the second paragraph of 35 U.S.C. 112:

The specification shall conclude with one or more claims particularly pointing out and distinctly claiming the subject matter which the applicant regards as his invention.

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6. Claim 11 recites the limitation "the graded composition of WSi" in line 1. There is insufficient antecedent basis for this limitation in the claim.

7. Claim 13 recites the limitation "first and second times" in line 1. There is insufficient antecedent basis for this limitation in the claim.

***Claim Rejections - 35 USC § 102***

8. The following is a quotation of the appropriate paragraphs of 35 U.S.C. 102 that form the basis for the rejections under this section made in this Office action:

A person shall be entitled to a patent unless –

(e) the invention was described in (1) an application for patent, published under section 122(b), by another filed in the United States before the invention by the applicant for patent or (2) a patent granted on an application for patent by another filed in the United States before the invention by the applicant for patent, except that an international application filed under the treaty defined in section 351(a) shall have the effects for purposes of this subsection of an application filed in the United States only if the international application designated the United States and was published under Article 21(2) of such treaty in the English language.

9. Claims 5-6 are rejected under 35 U.S.C. 102(e) as being anticipated by Mikagi (6,153,507). Mikagi teaches a method comprising: forming a conductive structure; Fig.6a, el.107a, forming a diffusion-barrier lining around the conductive structure after forming the conductive structure; fig.6c, el.108a, forming an insulative structure around the conductive structure after forming the diffusion-barrier lining; fig.6d, el.110a; and wherein forming the conductive structures comprises applying a copper-, silver-, or gold-based material; col.7, ln.54.

***Claim Rejections - 35 USC § 103***

10. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

(a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negated by the manner in which the invention was made.

11. Claim 8 is rejected under 35 U.S.C. 103(a) as being unpatentable over Mikagi as applied to claims 5-6 above, and further in view of Jin et al. (Materials Research Society; 1997). Mikagi appears not to specifically disclose forming the insulative structure comprises spin-coating an aerogel or xerogel. Jin teaches forming the insulative structure comprises spin-coating an aerogel or xerogel; p.465, par.2. It would have been obvious to one of ordinary skill in the art at the time of the invention to use the spin-coating method and materials of Jin with the structure formed by Mikagi, so as to form an insulative layer that has the properties of low moisture absorption, high dielectric strength, low stress, and good gap fill capability, see abstract of Jin.
12. Claims 9, 12-13 are rejected under 35 U.S.C. 103(a) as being unpatentable over Mikagi as applied to claims 5-6 above, and further in view of Beinglass et al. (5,940,733). Mikagi appears not to specifically state, wherein forming the diffusion-barrier lining comprises forming a graded composition of WSi<sub>x</sub>, where x varies from 2.0 to 2.5; nor wherein forming the diffusion-barrier lining comprises: introducing tungsten hexafluoride and hydrogen gases into a wafer processing chamber for a predetermined amount of time; nor introducing silane gas into the chamber a first predetermined time after introducing the tungsten hexafluoride gas; nor terminating introduction of the silane gas a second predetermined time before terminating introduction of the tungsten hexafluoride and hydrogen gases into the chamber; nor wherein the first and second times are in the range of about one to about three

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seconds. Beinglass teaches wherein forming the diffusion-barrier lining comprises forming a graded composition of  $WSi_x$ , where  $x$  varies from 2.0 to 2.5; col.4, ln.51-56, and wherein forming the diffusion-barrier lining comprises: introducing tungsten hexafluoride and hydrogen gases into a wafer processing chamber for a predetermined amount of time; and introducing silane gas into the chamber a first predetermined time; col.4, ln.33-50.

13. It would have been obvious to one of ordinary skill in the art at the time of the invention to combine Beinglass with Mikagi to form a graded diffusion barrier having reduced Silicon concentrations at the interfaces, so as to create more of a metal – metal interface, thus increasing the adhesion at the Cu-W interface and reducing the resistance of the interface and thus lowering the total resistance of the interconnect. Further, reduced silicon at the barrier/insulator interface would increase silicon diffusion from the insulator layer, thus increasing the bonding strength of the insulator to the barrier layer; col.1, ln.62 thru col.2, ln.14. Silicon gettering also would provide diffusion traps in the insulator region creating a better diffusion barrier.

14. It would have been obvious to one of ordinary skill in the art at the time of the invention to introduce silane gas into the chamber a first predetermined time after introducing the tungsten hexafluoride gas and terminating introduction of the silane gas a second predetermined time before terminating introduction of the tungsten hexafluoride and hydrogen gases into the chamber; and wherein the first and second times are in the range of about one to about three seconds, to decrease the silicon concentration at both interfaces of the barrier layer in order to increase adhesion,

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conductivity, and barrier effectiveness. The time delays of the first and second times are an optimization problem, well within the skill level of an ordinary artisan. Further, it is well known in the art that dopant concentrations can be reduced by merely shutting off the dopant source, and thus it would be obvious to shut off the silicon dopant source at those times in the barrier growth process at the times that the barrier layer interface layers are being formed. One would expect that such interface regions would amount to a few seconds of the deposition process.

15. Claims 10 and 11 are rejected under 35 U.S.C. 103(a) as being unpatentable over Mikagi and Beinglass as applied to claims 5, 6, 9, 12-13 above, and further in view of Hirata et al. (NTT System Electronics Laboratories). Mikagi and Beinglass appear not to disclose nitriding the graded composition of  $WSi_x$ ; nor wherein nitriding the graded composition of  $WSi$ , comprises exciting a plasma with argon gas. Hirata teaches nitriding a tungsten silicide layer, see introduction. It would have been obvious to one of ordinary skill in the art at the time of the invention to combine the teachings of Hirata with Mikagi and Beinglass to nitride the graded tungsten silicide barrier layer to further increase the barrier layer's capability to prevent the diffusion of Cu; see Hirata, section 2, par.3. Hirata teaches the Cu does not react with N, thus nitrogen stuffing the barrier layer is very beneficial to the teachings of Mikagi and Beinglass, and would be combined.

16. Further, It would have been obvious to one of ordinary skill in the art at the time of the invention to facilitate the use of the nitrogen stuffing process of Hirata with a carrier gas containing argon gas, col.4, ln.33-50, and exciting a plasma to order to

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increase the energy of the nitrogen atoms, to increase their reactivity, thus facilitating the ability of stuffing nitrogen into the barrier layer, thus improving the barrier layer's ability to stop the diffusion of copper.


### ***Conclusion***

17. Any inquiry concerning this communication or earlier communications from the examiner should be directed to Neal Berezny whose telephone number is (703) 305-1481. The examiner can normally be reached on M-F 9:00 - 5:30.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Olik Chaudhuri can be reached on (703) 306-2794. The fax phone numbers for the organization where this application or proceeding is assigned are (703) 308-7724 for regular communications and (703) 308-7724 for After Final communications.

Any inquiry of a general nature or relating to the status of this application or proceeding should be directed to the receptionist whose telephone number is (703) 308-0956.

NB  
March 23, 2003

  
Olik Chaudhuri  
Supervisory Patent Examiner  
Technology Center 2800